ON THE STRUCTURE OF THE SPIRACLES OF A TICK—*HAEMAPHYSALIS PUNCTATA*, Canestrini and Fanzago.

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Plates XXII, XXIII.

The detailed structure of the spiracles in the Ixodoidea has hitherto received little or no attention at the hands of zoologists; at the same time, these organs are sufficiently extraordinary to make it a matter of surprise that, so far as our knowledge of the literature goes, not one of the numerous contributors to the subject of tick anatomy has found it worth while to undertake a complete description or to publish figures to illustrate it. Batelli (1891) gives a short account of the structure of the spiracle of a tick, presumably *Ixodes ricinus*, with a single figure, but with this exception we have been unable to find any further information on the subject.

The material for this communication has been accumulated in the course of our work on the anatomy of ticks, and in view of the interesting features presented by the spiracles, we have preferred to publish a separate account of these structures, although a more or less general description will appear later in the second part of our paper on the anatomy of *Haemaphysalis punctata*[1].

The spiracles are situated in the posterior half of the body, on the lateral margins, towards the ventral surface, immediately behind and a little external to the coxae of the fourth pair of legs. Each consists of a slightly elevated "plaque" with a well-defined margin. The dimensions of the spiracle show a considerable amount of variation; in the adult tick the length of the spiracle usually exceeds the breadth, in the nymph the reverse is the case. The following table gives the actual dimensions in both sexes and the nymphal stage, measured on ten specimens of each taken from a large number collected in Kent.

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[1] See this volume, pp. 152—181.

Dimensions of Spiracle in Haemaphysalis punctata.

(In microns.)

Male		Female		Nymph	
Length	Breadth	Length	Breadth	Length	Breadth
510	320	500	430	160	170
500	310	460	410	160	160
500	310	430	360	160	150
500	300	410	400	150	170
490	350	400	360	150	170
480	330	390	360	140	160
470	320	360	350	140	150
460	270	350	320	140	150
440	260	340	320	130	150
430	270	330	330	130	140

The contour of the spiracle differs in the three cases, although in the case of the male an approach in shape to the female type may be frequently observed. The spiracle of the female (Pl. XXII, fig. 1) is more or less angular in outline, this being due to a flattening of the contour of the lateral margin; that of the male has a more or less rectangular figure and becomes gradually narrower towards its posterior portion. The spiracle of the nymph is almost circular, with a slight rounded angle at the postero-lateral margin.

The surface of the spiracle is slightly concave with the exception of a small central area, the macula (Pl. XXII, figs. 1 and 2), dark in colour and slightly eccentric in position, situated a little towards the antero-mesial margin. The macula is elliptical in outline and placed obliquely with the major axis inclined at an angle of about 45° to the median axis of the body, the anterior end being directed outwards. The marginal portion of the spiracle is formed of dark-coloured chitin, and the area between this margin and the macula, of a pale greyish-yellow colour, is perforated by numerous regularly-distributed minute pores (*e.p.*); these are best seen by examination of uncleared specimens in reflected light. A limited number of coarser pores open on the marginal portions of the plate (*m.p.*). The macula of the spiracle of the female is cleft by a large slit-like opening which we have termed the ostium (Pl. XXII, figs. 1, 2 *os.*); the extremities of the latter are curved round in a crescentic manner with a convexity towards the antero-mesial margin of the spiracle. It is bounded on its external side by a prominent raised lip (Pl. XXIII, figs. 5—7), which overhangs the opening and effects its closure when the lip is depressed by muscular action. The ostium does not appear in the male or nymph[1].

It is only when cleared and mounted specimens of the entire spiracle are examined that its complex structure becomes apparent. That which on examination *in situ* appears to be a simple sieve-like plate, resolves itself into a series of three superposed layers, each differing from the other two in structure. The superficial layer exhibits a regular reticulate pattern which, as will be seen later, is due to a thickening of the chitin on its under surface; the meshes of this reticulum are more or less circular, and each is perforated in its central portion by one of the minute pores (*e.p.*) already alluded to. It is almost impossible to define these pores in cleared entire preparations of the spiracle on account of their extremely thin margins being obscured by the underlying parts. Immediately beneath the superficial layer is a large air space, traversed by an arrangement of innumerable delicate chitinous rods or pedicels (*p.*), the slightly expanded bases of which arise from a thick basal layer of chitin, the latter forming the deepest layer and the most substantial portion of the spiracular plate. The basal layer, like the superficial layer, is porose, but its pores (*i.p.*) are not pervious to air, being occupied by protoplasmic extensions from the hypodermal cells underlying the spiracle. The internal pores coincide in position with the superficial pores and are those seen in ordinary cleared and mounted preparations. The intermediate or pedicellar layer is formed by the system of pedicels which support the superficial layer. The arrangement of the pedicels shows a regular system; this is readily seen in Pl. XXII, figs. 2 and 4. The pedicels are triangular in cross section and are slightly curved in such a manner that their upper extremities are brought together and fuse with one another on the under surface of the superficial layer; it is this fusion of the pedicels which forms the reticulate thickening of the superficial layer.

By the study of a series of vertical transverse and longitudinal sections of the spiracle, it becomes possible to interpret the relationship of the parts described in the preceding paragraph (Pl. XXII, fig. 3 and Pl. XXIII, figs. 1—10). The continuity of the thin superficial layer is broken at intervals by the external pores (*e.p.*) and directly beneath the latter are seen the internal pores (*i.p.*) passing through the basal layer. Large pyriform air spaces are formed between the groups of pedicels beneath each of the external pores, and these pyriform spaces (*p.s.*) establish direct communication between the two series of external and internal pores.

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[1] The terms macula and ostium are both new: the term pore has been very loosely used in general descriptions and appears to refer to the macula. We see, however, that the macula may contain no pore or aperture communicating with the tracheal system.

The portion of the spiracle beneath the macula shows an entirely different structure. It is occupied by a columnar mass of connective tissue and muscle fibres running upwards from the soft structures underlying the spiracle; this mass of soft tissue, which we have termed the columella, extends up to the under surface of the superficial layer which is considerably thickened at this central portion (Pl. XXIII, figs. 7—10 *col.*). Completely encircling the columella is a large annular air space, the pericolumellar space (*pc.s.*) which communicates directly with the interstices between the pedicels in the intermediate space. The ostium opens into the pericolumellar space on the internal side of the columella (Pl. XXIII, figs. 5—7) and immediately beneath the ostium the cavity of the pericolumellar space is continued downwards as a large chamber of irregular shape which we have termed the atrium (*a.*). The cavity of the atrium is roughly elliptical in cross section, somewhat contracted dorso-ventrally; its direction is at first horizontal or slightly upwards, it then bends downwards and terminates abruptly, the entire length being equal to about half the diameter of the spiracle. Numerous main tracheal trunks (*tr.*) open separately from the basal portion of the atrium, running inwards and downwards for a short distance as a stout bundle of tubes with spirally thickened walls, from which the tracheae radiate to all parts of the body. Running up the columella and inserted along the dorsal wall of the atrium (to the right of the atrium in the figures on Pl. XXIII) is a band of muscle fibres, a small portion of which runs up to the superficial layer and is inserted beneath the centre of the macula. The contraction of this columellar muscle would dilate the cavity of the atrium and possibly at the same time close the ostium, the external margin of which overhangs the slit-like opening. This would cause the inspired air to filter through the external pores of the superficial layer. The expulsion of air from the tracheal system is effected by the contraction of the dorso-ventral body muscles which squeezes the contained air out through the spiracle, a fresh supply being inspired by the elastic rebound of the tracheal tubes, when the action of the body muscles is relaxed.

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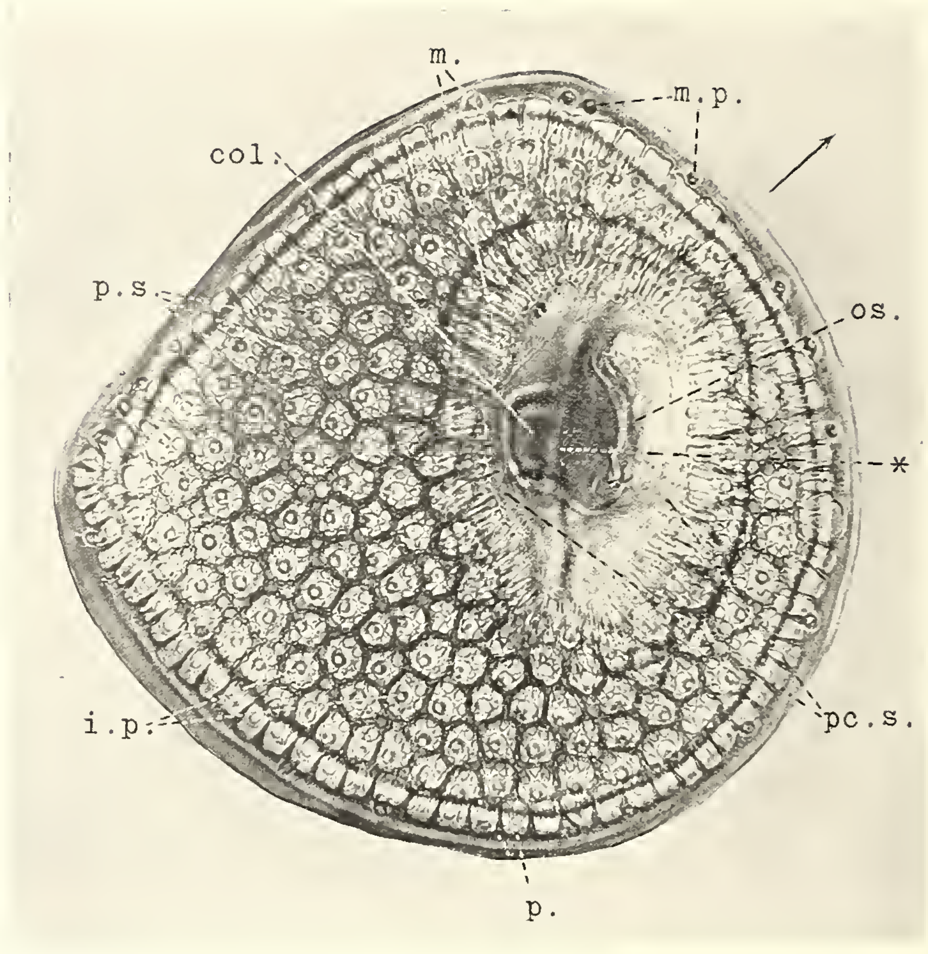


Fig. 1.

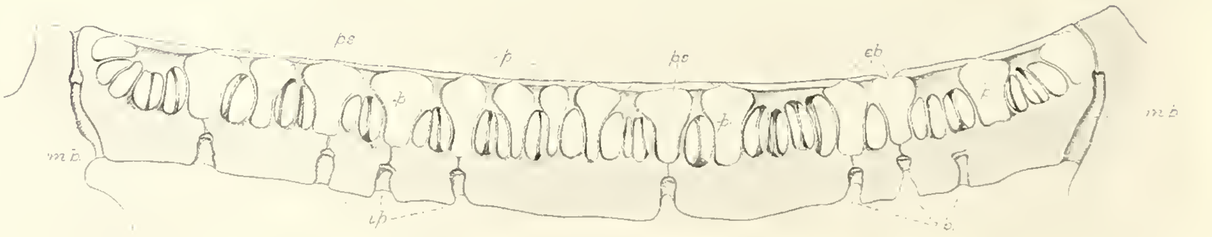


Fig. 3.

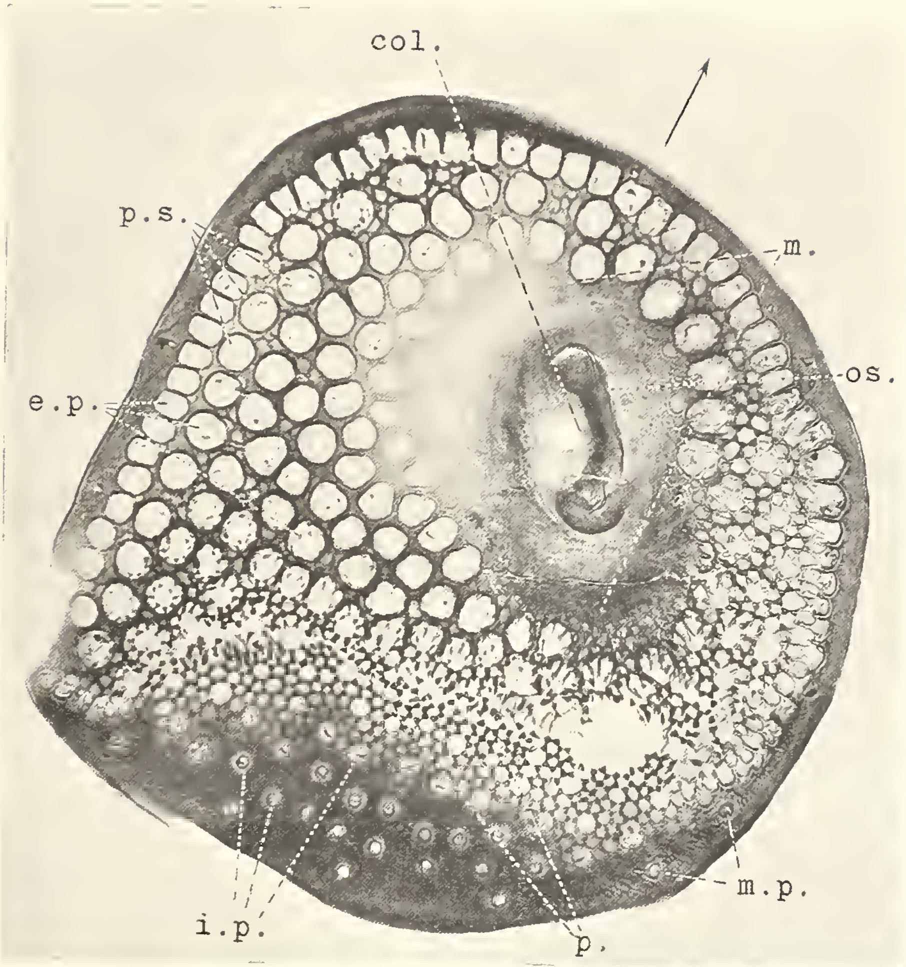


Fig. 2.

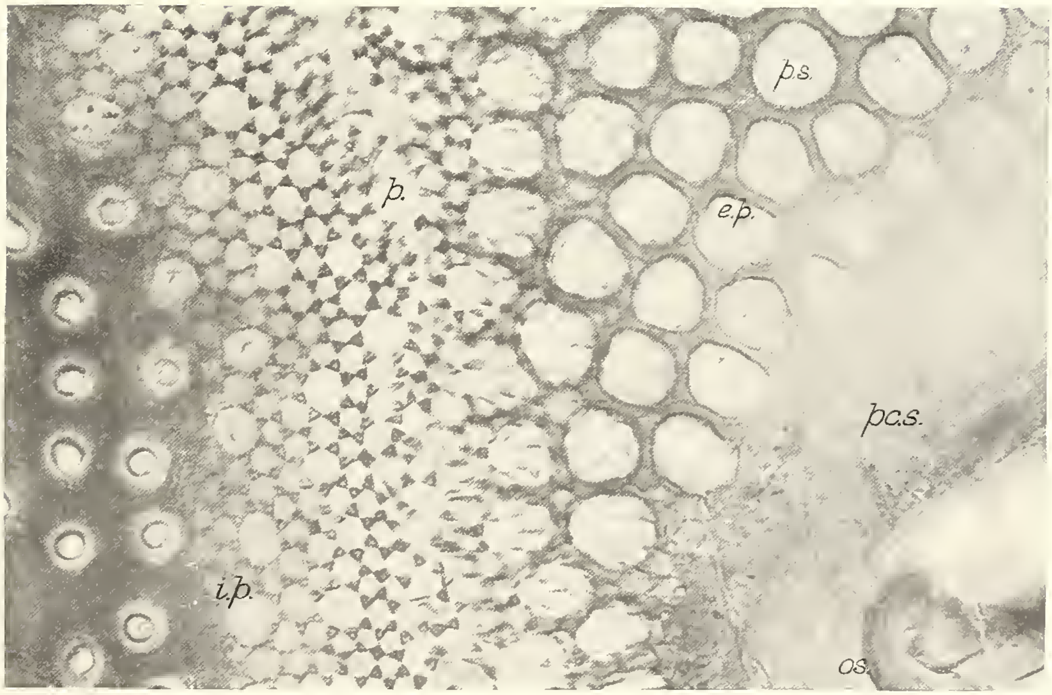


Fig. 4.

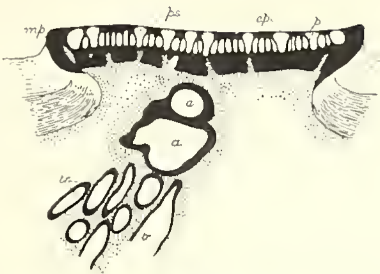


Fig. 1.

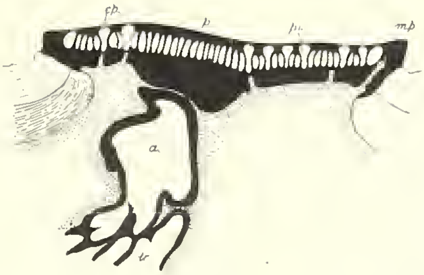
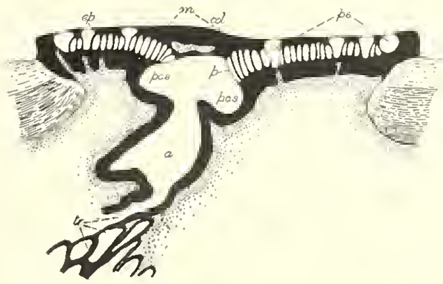


Fig. 2.



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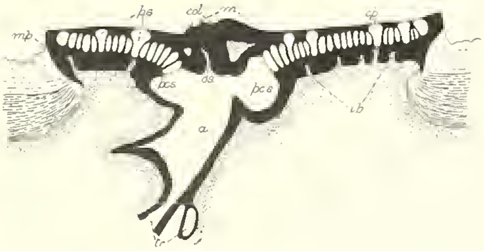

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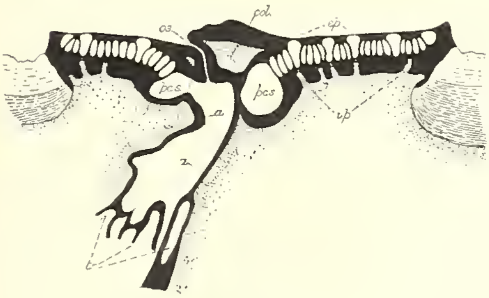


Fig. 5.

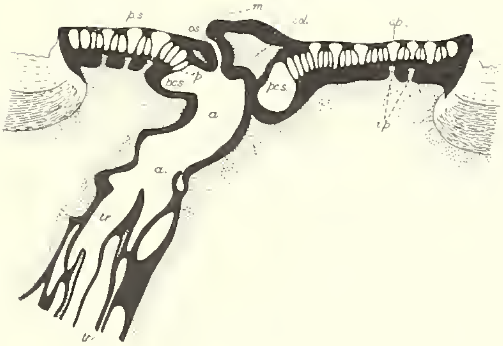
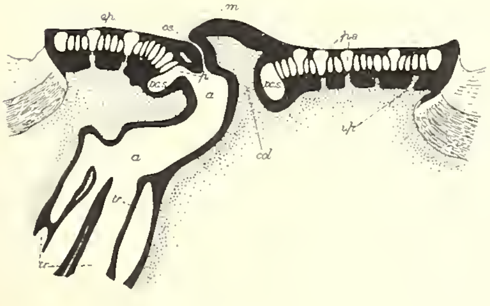


Fig. 6.



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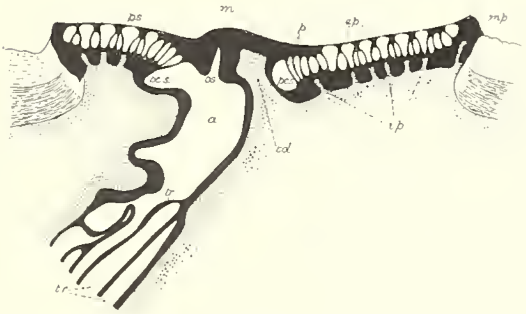

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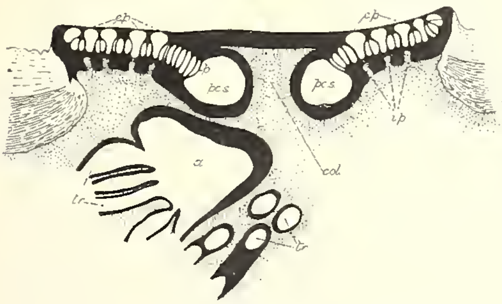

Fig. 9.

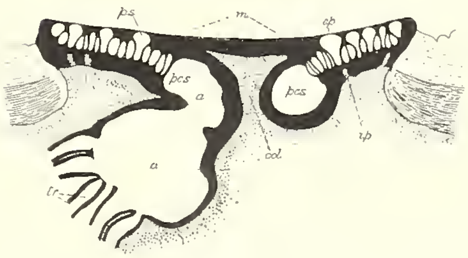

Fig. 10.

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Batelli, A. (1891). Note anatomo-fisiologiche sugli Ixodini. Communicazione Preventiva (second part). *Monitore Zoologico Italiano*, II. 1 figure in text.

Nuttall, G. H. F., Cooper, W. F. and Robinson, L. E. (1908). The structure and biology of *Haemaphysalis punctata*, Canestrini and Fanzago. I. *Parasitology* I. pp. 152—181, Pls. XII—XVI and figs. in text.

DESCRIPTION OF PLATES XXII—XXIII.

PLATE XXII.

Fig. 1. *Haemaphysalis punctata* ♀. Right spiracle as seen in transmitted light; the arrow indicates the direction of longitudinal axis. Photomicrograph (L. E. R.) × 220.

Fig. 2. *Haemaphysalis punctata* ♀. Horizontal section through right spiracle passing in a slightly oblique plane and cutting the different layers successively; the arrow indicates the direction of the longitudinal axis. Photomicrograph (L. E. R.) × 220.

Fig. 3. *Haemaphysalis punctata* ♀. Transverse section through spiracle (not passing through macula) showing characters of external, internal and marginal pores. (L. E. R. del.) × 300.

Fig. 4. Small portion of Fig. 2, highly magnified, showing regular arrangement of pedicels, etc. Photomicrograph (L. E. R.) × 500.

PLATE XXIII.

Chitinous structures of spiracle—black: general cuticle of body—line-shaded: soft tissues—stippled: air spaces—clear.

Figs. 1—8. *Haemaphysalis punctata* ♀. A series of transverse sections passing through the central portion of the spiracle, showing communications between the various air spaces, the atrium and tracheae, etc. × 100.

Figs. 9—10. *Haemaphysalis punctata* ♀. Longitudinal sections passing through the macula on external side of ostium, Fig. 10 being the more internal of the two. × 100.

INDEX TO LETTERING ON PLATES XXII—XXIII.

a.	atrium.
col.	columella.
e. p.	external pores.
i. p.	internal pores.
m.	macula.
m. p.	marginal pores.
os.	ostium.
p.	pedicels.
p. s.	pyriform spaces.
pc. s.	pericolumellar space.
tr.	tracheae.
* (Pl. XXII, Fig. 1)	indicates external wall of atrium, seen through thickness of spiracular plate.

The arrows on Pl. XXII, Figs. 1 and 2 indicate the direction of the longitudinal axis of the spiracle.